FEASIBILITY STUDY ON THE USAGE OF THE NATURAL GAS FOR ELECTRICITY SUPPLY AT UNIVERSITI MALAYSIA PAHANG (UMP) GAMBANG CAMPUS

MUHAMMAD ZULHILMI BIN MOHD ITHNIN

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ABSTRACT

Natural gas is one of the energy sources which are more effectives and cheap compare to electricity. The main objective of this thesis is to study the feasibility of natural gas usage as an alternatives energy source to generate electricity to Block Taman Teknologi Industri (TTI) and Block A, B, and C at University Malaysia Pahang (UMP) Gambang Campus. Block TTI is consists of ex-cancelori building and main laboratory of Faculty of Chemical Engineering and Natural Resources (FKKSA) and Faculty of Industrial Science and Technology (FIST). While, Block A, B, and C consists of office buildings, classrooms and lecture hall. There are air conditioner at lecture hall, classroom and offices and also boiler and absorption chiller in laboratory. To support the cost of operation of all these are relatively expensive resulting high electricity bill for UMP every month. This study will compare between the alternatives energy sources which is natural gas with electricity power with the intention of reducing the energy cost. The scopes of this project are to determine the gas consumption and demand, cost for introducing natural gas to the system which consist of piping and construction cost. The method that been used are to construct the economic analysis by using basic financial assessment. SPSS 17.0 software is run for data analysis. From the analysis, it was found that the margin for operational cost of natural gas has significant difference which is lower than operational cost for electricity. The total annual profit, the total annual saving and payback period is also discussed in this paper. The calculation result of economic analysis shows that the introducing natural gas as an alternatives energy source has a good economic benefits.

ABSTRAK

Gas asli merupakan salah satu daripada punca tenaga yang lebih efektif dan murah berbanding dengan sumber elektrik sedia ada. Objektif utama bagi tesis ini adalah untuk membuat kajian tentang kesesuaian menggunakan alternatif bagi punca tenaga iaitu gas asli untuk menghasilkan arus elektrik bagi bangunan taman teknologi industri (TTI) dan juga bangunan A, B, A dan C di Universiti Malaysia Pahang (UMP) kampus Gambang. Bangunan Taman Teknologi Industri (TTI) meliputi bangunan lama canselori dan makmal utama Fakulti Kejuruteraan Kimia dan Sumber Asli (FKKSA) dan juga Fakulti Industri Sains dan Teknologi (FIST). Manakala, bangunan A, B, dan C pula meliputi bangunan pejabat, bilik belajar dan juga dewan kuliah. Terdapat penyaman udara yang digunakan di dewan kuliah, bilik belajar dan juga pejabat serta alat pemanas air serta penyerap dingin digunakan di makmal. UMP terpaksa menanggung jumlah bil electrik yang tinggi setiap bulan untuk menampung kos penggunaan bagi bangunan-bangunan tersebut. Kajian ini telah membandingkan penurunan harga bagi tenaga elektrik yang dihasilkan oleh gas asli sebagai salah satu alternatif lain bagi punca tenaga dengan aliran tenaga dari system sedia ada. Skop yang merangkumi projek ini adalah menentukan penggunaan dan keperluan elektrik dan kos sistem gas asli yang merangkumi sistem perpaipan dan kos penyelenggaraan. Kaedah yang digunakan dalam kajian ini adalah menganalisis ekonomi menggunakan penilaian asas kewangan. Manakala, SPSS 17.0 digunakan dalam menganalisis data. Hasil daripada analisis yang dijalankan, terdapat julat kos penggunaan elektrik yang ketara diantara sistem gas asli dan sistem sedia ada. Manakala, jumlah keuntungan tahunan, jumlah simpanan tahunan dan juga tempoh bayaran semula turut dibincangkan di dalam tesis ini. Hasil pengiraan bagi analisis ekonomi menunjukkan bahawa pengenalan untuk menggunakan gas asli sebagai salah satu alternatif bagi sumber tenaga mempunyai nilai keuntungan ekonomi yang baik.

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LIST OF SYMBOLS

i	Interest rate market value
∞	Infinity number
N	Degree of polynomial
n	Value of year
t	Period of time
Ft	Profit or net cash flow in year t
F_0	Present worth of the investment
H_0	Null hypothesis

LIST OF ABBREVIATIONS

ASTM	American Society of Testing and Materials
API	American Petroleum Institute
CCHP	Combined cooling heat power
FCI	Fixed capital investment
GRC	Grass root capital
IRR	Internal rate of return
JPPH	Jabatan Pembangunan Pengurusan Harta
kPa	KiloPascal
kW	Kilo watt
kWh	Kilowatt hour
MTOE	Million tons of oil equivalent
MWh	Megawatt hour
MMBtu	Million metric British thermal unit
NG	Natural gas
NPV	Net present value
NPS	National Petroleum Standard
PE	Polyethylene
psia	pound(s) per square inch absolute
psig	ponds(s) per square inch gauge
ROI	Return on investment

SPB	Simple payback period
SPSS	Statistical package for the social sciences
TCI	Total capital investment
TTI	Taman Teknologi Industri

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

The natural gas demand as a fuel to generate electricity is increasing due to abundance resources compared to other fuel, environmental friendly (clean burning), efficiency and low cost compared to other fuel or electricity. On the other hand, for example in term of transmission line, the electric power in current from the power plant will loss and need a generator to power up the current to make sure the current is supplied to customer. So, it is more expensive because of the cost to generate the current. For natural gas, the gas will flow through the transmission line without having a loss of load. With using the natural gas, it will reduce the pollution and increase the consciousness and responsibility to the environment in our country. It is important to consider the environment to make sure we have the brighter future towards sustainable development for our country.(Oh T. H., Pang S. Y., Chua S. C., 2009)

Natural gas is not only can generate electricity, it also can use for water heating and boiling, cooking, drying, production of steam and so on. It is suitable for household, commercial, and industrial utilizations. Many new and improved application of natural gas have been in the market. The function of these applications depends on the equipment and alternative fuel cost, and local regulatory condition.(Jaafar M. Z., Kheng W. H., Kamarudin N., 2003)

1.2 PROBLEM STATEMENT

Universiti Malaysia Pahang (UMP) Gambang Campus is a small campus which has an approximately 6000 students. All of the lecture hall, classroom, and offices are using air – conditioning. The main laboratory is using a chiller unit for the air conditioning which consumed substantial amount of electricity to operate. In the Faculty of Chemical and Natural Resources Engineering (FKKSA) laboratory, there are boiler and absorption chiller which are also currently using electricity to operate. In order to support the cost of operation of all these equipments are relatively expensive. This resulted high electricity bill for UMP Gambang Campus every month.

Other than conventional electricity power, one is going to find alternatives power source that can reduce this cost. The alternative power that has the potential is natural gas. This study will compare between the alternative power sources which is natural gas with electricity power with the intention of reducing the power cost. Electrical power obtained from the transmission grid is known to have substantial power lost between the powers generating plant to the consumer point. This power lost may be as high as 40% [1] and this is made the electricity cost is even higher. By using cogeneration system, it is anticipated that it can increase the energy efficiencies and also reduce the cost of electricity for Universiti Malaysia Pahang (UMP) Gambang Campus.

1.3 OBJECTIVES

The objectives of this study are:

1. To study the cost of electricity consumption before and after the natural gas installation for Universiti Malaysia Pahang (UMP) Gambang Campus.

2. To study the economic analysis for natural gas as alternatives power source to generates electricity for Universiti Malaysia Pahang (UMP) Gambang Campus.

1.4 SCOPE OF STUDY

In this thesis, the scopes of the study are:

1. Electricity and heat consumption

    Analyze the usage and consumption of electricity and heat in Universiti Malaysia Pahang (UMP) Gambang Campus. This is includes all the electricity cost and bill for electricity usage for Universiti Malaysia Pahang (UMP) Gambang Campus for block TTI (Taman Teknologi Industri) and block A, B and C within 12 month for 2010. Possibilities of using natural gas as an alternative power source to Universiti Malaysia Pahang (UMP) Gambang Campus also will also be determined.

2. Cogeneration system

    Determine the correct cogeneration system based on the power and heat consumption for Universiti Malaysia Pahang (UMP) Gambang Campus.

3. Cost

    The capital cost of natural gas construction and cogeneration which is including current prices of natural gas, current price of pipeline and current price of cogeneration system. It is more effective when the cost of gas construction is small and at the same time the safety aspect is attached together. In short, safety aspect is included with low cost of gas construction.

1.5 RATIONAL AND SIGNIFICANCE

1.5.1 Rational

The usage of natural gas will affect the cost of electricity bill for UMP Gambang Campus every month. It also can also produce cleaner environment due to the clean combustion.

1.5.2 Significance

The natural gas price is cheaper and the efficiency is up to 90 % compared to other fuel.

CHAPTER 2

LITERATURE REVIEW

2.1 NATURAL GAS

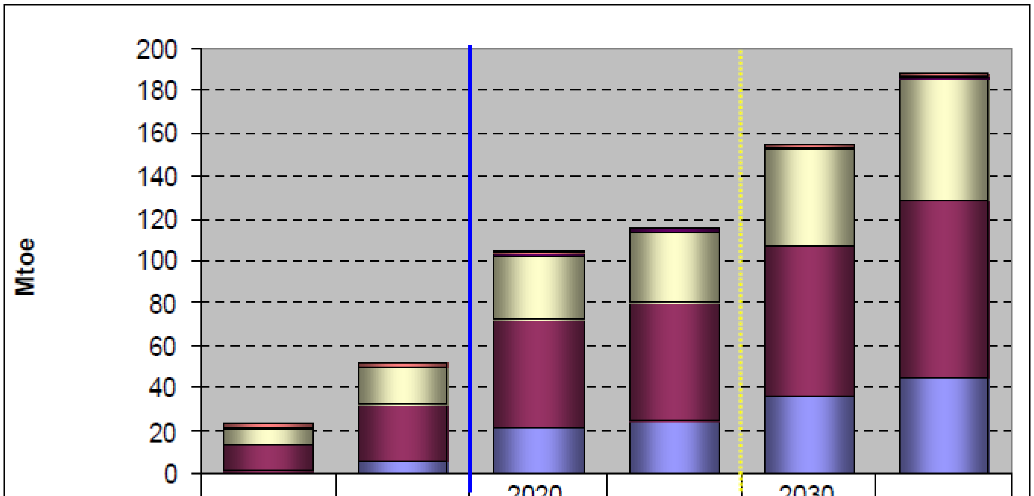
Natural gas is considered a fossil fuel and consists of methane (CH_4). It may also contain ethane (C_2H_6), propane (C_3H_8), butane (C_4H_{10}) and others. It has certain properties that enable its use for industrial or domestic purpose, such as, contains non-poisonous ingredients that when inhaled gets absorbed into our body. It is also tasteless and colourless and when it mixed with suitable amount of air and ignited, it will burn with clean blue flame. It is considered as the cleanest burning fuels and producing carbon dioxide and water as same as breathing. Natural gas is lighter than air (SG_{NG}=0.6, SG_{air}=1.0), and tends to disperse into the atmosphere. (A. Roley, 1997)

Natural gas only ignites when there is an air and gas mixture and the percent of natural gas is between 5 to 15 percent. A mixture containing less or greater, natural gas would not ignite. Natural gas contains very small quantities of nitrogen (N_2), carbon dioxide (CO_2), sulfur components and water. It leads to the formation of a pure and clean burning product that is efficient to transport. (Gas Malaysia Sdn Bhd)

Natural gas (methane, ethane, propane, and butane) was the most famous and the best fuel for hydrogen rich gas production due its composition from lower molecular weight. They found that the highest fuel processing efficiency was achieved with natural gas steam reforming at about 98%. (Ersoz et al, 2006)

Natural gas is a major source of electricity generation through the use of gas turbines and steam turbines. Particularly high efficiencies can be achieved through combining gas turbines with a steam turbine in combined cycle mode. Natural gas burns cleaner than other fossil fuels, such as oil and coal, and produces less carbon dioxide per unit energy released. For an equivalent amount of heat, burning natural gas produces about 30% less carbon dioxide than burning petroleum and about 45% less than burning coal. (Ersoz et al, 2006)

Combined cycle power generation using natural gas is thus the cleanest source of power available using fossil fuels, and this technology is widely used wherever gas can be obtained at a reasonable cost. Fuel cell technology may eventually provide cleaner options for converting natural gas into electricity, but as yet it is not price-competitive. Also, the natural gas supply is expected to peak around the year 2030, 20 years after the peak of oil. It is also projected that the world's supply of natural gas could be exhausted around the year 2085. (Ersoz et al, 2006)



	1990	2005	2020 Reference	2020 High	2030 Reference	2030 High
Others	2.1	1.3	0.7	0.7	0.6	0.6
Hydro	0.3	0.5	1.6	1.6	1.6	1.6
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0
Natural gas	6.8	17.2	29.6	33.4	46.2	57.1
Oil	13.0	26.7	51.2	56.1	70.5	83.5
Coal	1.0	5.9	21.3	24.2	35.9	45.3

Figure 2.1: Primary energy consumption by energy type in MTOE

Source: The 2nd ASEAN Energy Demand Outlook (2009)

Figure 2.1 showed the primary energy consumption in Malaysia for 2005. Historically, the primary energy consumption of Malaysia increased from 23.322 MTOE in 1990 to 51.558 MTOE in 2005. This is an average increase of 5.4 percent per annum. For the reference scenario, Malaysia's primary energy consumption is expected to grow at an annual rate of 4.5 percent from 2005 until 2030. Natural gas that was consumed mostly by the thermal stations, industry and for non-energy purposes will be expected to grow at 4.0 percent per annum from 2005 until 2030. However, the share of natural gas in primary supply mix will be expected to be reducing from 33.3 percent in 2005 to 29.9 percent in 2030.

In the high scenario, the projected primary energy consumption will increase at a higher rate of 5.3 percent per annum from 2005 until 2030. Natural gas is expected to increase at a faster rate of 4.9 percent respectively. These increases will be driven by the rapid growth in consumption in power generation. (ASEAN, 2009)

2.2 ECONOMICS OF COGENERATION SYSTEM

The principle behind cogeneration is simple. Conventional power generation, on average, is only 35% efficient – up to 65% of the energy potential is released as waste heat. More recent combined cycle generation can improve this to 55%, excluding losses for the transmission and distribution of electricity. Cogeneration reduces this loss by using the heat for industry, commerce and home heating and cooling. (Gas Malaysia Sdn. Bhd, 2009)

Cogeneration is the simultaneous generation of heat and power, both of which are used. It encompasses a range of technologies, but will always include an electricity generator and a heat recovery system. Cogeneration is also known as combined heat and power (CHP). (EDUCOGEN, 2001)

Through the utilization of the heat, the efficiency of cogeneration plant can reach 90% or more. In addition, the electricity generated by the cogeneration plant is normally used locally, and then transmission and distribution losses will be negligible. Cogeneration therefore offers energy savings ranging between 15-40% when compared against the supply of electricity and heat from conventional power stations and boilers. (EDUCOGEN, 2001)

2.2.1 Cogeneration Technologies

Cogeneration plant consists of four basic elements which is a prime mover (engine), an electricity generator, a heat recovery system and a control system. The prime mover may be a steam turbine, reciprocating engine or gas turbine. The prime mover drives the electricity generator and waste heat is recovered. Cogeneration units are generally classified by the type of prime mover (drive system), generator and fuel used. Example drive systems for cogeneration units include steam turbines, reciprocating engines, and gas turbines and combined cycle.

Steam turbines commonly used as prime movers for industrial cogeneration systems. High-pressure steam raised in a conventional boiler is expanded within the turbine to produce mechanical energy, and then be used to drive an electric generator. The power that produced depends on how much the steam pressure can be reduced through the turbine before being required by site heat energy needs. This system generates less electrical energy per unit of fuel than a gas turbine or reciprocating engine-driven cogeneration system, although it's overall efficiency may be higher. Steam turbines fall into two types, which is back - pressure turbines and condensing turbines. These two types of steam turbines are based on exit pressure of the steam from the turbine:

The gas turbine has become the most widely used prime mover for large-scale cogeneration in recent years. A gas turbine based system is much easier to install on an existing site. A weighing heavily factor in favor of gas turbines together with reduced capital cost and the improved reliability of modern machines, often makes gas turbines the optimum choice. The fuel is burnt in a pressurized combustion chamber using combustion air supplied. The hot pressurized gases are used to turn a series of fan blades, and the shaft on to produce mechanical energy. Residual energy in the form of a high flow of hot exhaust gases can be used to the thermal demand of the site. The available mechanical energy can be applied to produce electricity with a generator or to drive pumps, compressors, and blowers.

Finally, the reciprocating engines or usually known as gas engine used in cogeneration are internal combustion engines. Reciprocating engines give a higher electrical efficiency, but it is more difficult to use the thermal energy they produce, since it is generally at lower temperatures and is dispersed between exhaust gases and engine cooling systems. The heat recovered from the cooling circuits and exhaust gases is cascaded together to produce a single heat output, typically producing hot water. There are two types of reciprocating engine which is compression – ignition engines and spark – ignition engines. These two types of engines were classified by their method of ignition.

Table 2.1 summaries the main types of systems available, together with their typical size range, heat to power ratio, efficiency and heat quality.

Table 2.1: Typical cogeneration systems for different prime mover

PRIME MOVER	FUEL USED	SIZE RANGE (MWe)	HEAT: POWER RATIO	ELECTRICAL GENERATING EFFICIENCY	TYPICAL OVERALL EFFICIENCY	HEAT QUALITY
PASS OUT STEAM TURBINE	ANY FUEL	1 to 100+	3:1 to 8:1+	10 - 20%	UP TO 80%	STEAM AT 2 PRESS OR MORE
BACK PRESSURE STEAM TURBINE	ANY FUEL	0.5 to 500	3:1 to 10:1+	7 - 20%	UP TO 80%	STEAM AT 2 PRESS OR MORE
COMBINED CYCLE GAS TURBINE	GAS BIOGAS GASOIL LFO LPG NAPHTHA	3 to 300+	1:1 to 3:1*	35 – 55%	73 - 90%	MEDIUM GRADE STEAM HIGH TEMPERATUR E HOT WATER
OPEN CYCLE GAS TURBINE	GAS BIOGAS GASOIL HFO LFO LPG NAPHTHA	0.25 to 50+	1.5:1 to 5:1*	25 – 42%	65 – 87%	HIGH GRADE STEAM HIGH TEMPERATUR E HOT WATER
COMPRESS. IGNITION ENGINE	GAS BIOGAS GASOIL HFO LHO NAPHTHA	0.2 to 20	0.5:1 to 3:1* Alfa value 0.9-2	35 – 45%	65 - 90%	LOW PRESSURE STEAM LOW AND MEDIUM TEMPERATUR E HOT WATER
SPARK IGNITION ENGINE	GAS BIOGAS LHO NAPHTHA	0.003 to 6	1:1 to 3:1 Alfa value 0.9-2	25 - 43%	70 - 92%	LOW AND MEDIUM TEMPERATUR E HOT WATER

Source: EDUCOGEN Europe (2001)

2.2.2 Cogeneration selection

Feasibility studies have shown that reciprocating engines or gas engine is suitable for this study. The cogeneration consists of gas engine combined cooling heat & power (CCHP) and gas – fired absorption chiller where electricity produced was selected based on the total power to heat ratio suitable for building sectors. The low pressure steam or medium or low temperature hot water is required for producing lower grade recovery heat suitable for hot water or steam using in the laboratory.

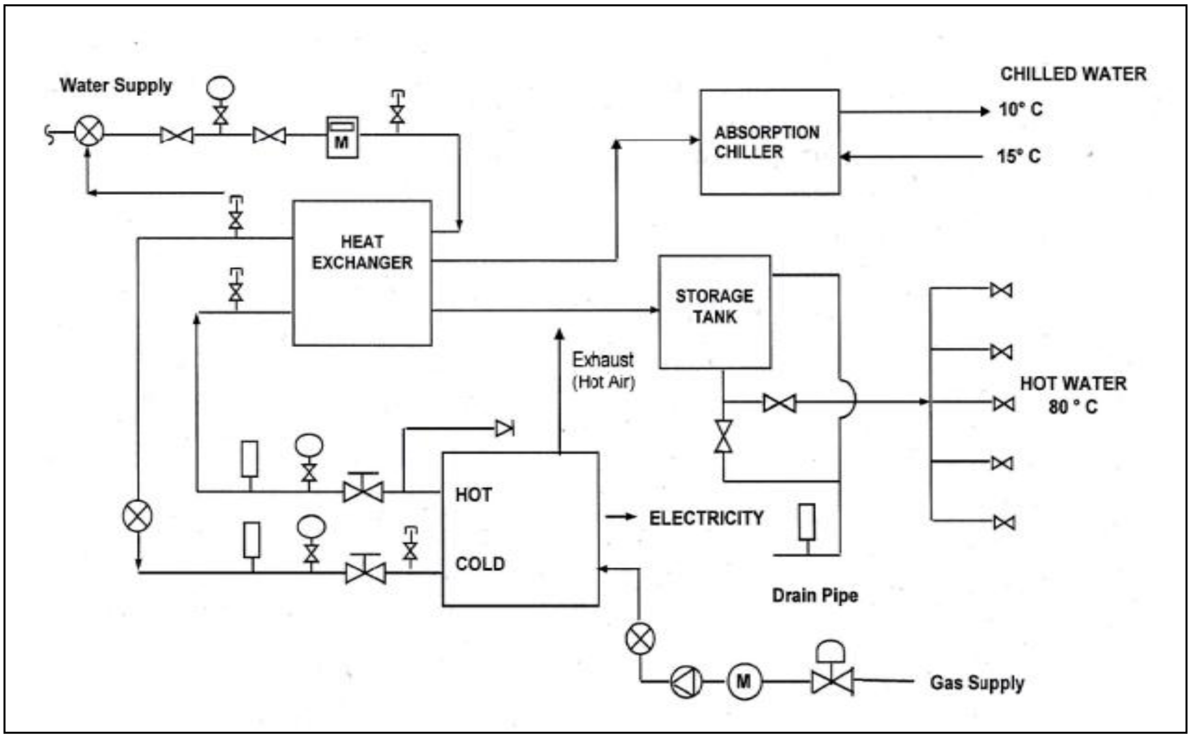


Figure 2.2: Gas engine – CCHP application

Source: Gas Malaysia Sdn. Bhd (2010)